N75 13757

THE GEOLOGY OF MARS

Michael H. Carr
U.S. Geological Survey, Menlo Park, Calif. 94025

The Mariner 9 mission revealed Mars to be a much more diverse planet geologically than had been anticipated. Unlike the Earth and the Moon, the planet preserves on its surface a seemingly continuous record of dynamic activity from the late stages of accretion to the present day. Large volcanoes of widely different ages and extensive fracture systems attest to a long history of internal activity while the preservation of large areas of primitive densely cratered terrain indicates that crustal mobility and erosional processes have been far less effective than on Earth in destroying the early record. Perhaps the greatest surprise of Mariner 9 was the discovery of fluvial-like features. Since liquid water is unstable under present conditions at the Martian surface, the presence of the channels indicates either an origin other than aqueous or climatic conditions in the past that were quite different from those that presently prevail. The great canyons and numerous cliff-like features suggestive of active erosion were also surprises, as were the widespread layered deposits at the poles. The significance of these unexpected results is still far from understood, and the planet remains a fertile field for speculation.

The surface of Mars can be divided into two hemispheres: one exhibiting nearly all the primitive cratered terrain; the other, nearly all the young shield volcanoes and volcanic plains. The division is not exclusive but generally holds. At the boundary between the two hemispheres, the primitive cratered terrain appears dissected and broken into numerous buttes and mesas. At greater distances from the boundary into the young plains, the mesas become smaller and more dispersed until finally none remain. Although the present boundary appears to be the product of erosion, it may have resulted initially from early fractionation of the crust.

The large, young shield volcanoes are concentrated into two regions, Tharsis and Elysium. The Tharsis shields are enormous by terrestrial standards, Olympus Mons being 23 km above the surrounding plains. The large size compared to terrestrial counterparts is believed to result from an absence of crustal plate motion and the great depth of magma origin. Lines of strato volcanoes are absent on Mars, but since on Earth these are generally located above subduction zones, their absence on Mars is not surprising. The NE-SW alignment of the Tharsis shield may be related to a general updoming of the Tharsis region. The dome, approximately 4000 km across and 7 km high at the summit, is at the center of a vast fracture system that encompasses almost half the planet. The fractures are crudely radial to the Tharsis region and appear to have formed before the onset of the main shield building period in Tharsis. Shield volcanoes older than the fracture system do occur but do not achieve heights comparable to the shields that post-date the fractures. Although the shield volcanoes are the most spectacular examples of volcanism, the plains may be more significant volumetrically. On high-resolution frames of the plains, long subdued lobate scarps are common. They resemble those found on the lunar maria and are widely interpreted as flow fronts. Older plains units that occur in the intercrater areas of the primitive cratered terrain, also may be volcanic in origin, but because they lack the characteristic flow features, their origin is much more uncertain. Less ambiguous examples of volcanism in the primitive cratered terrain are subdued, heavily cratered shield-like structures.

PRECEDING PAGE BLANK NOT FILMED

The large canyon of Mars (Valles Marineris) is aligned along the direction of the Tharsis fractures; thus, its orientation appears to be fracture controlled. It is not, however, purely tectonic in origin; secondary processes such as aeolian and fluvial action almost have certainly contributed to its present dimensions. At the eastern end of the canyon (downslope) are wide areas of chaotic terrain. The surface has been broken into numerous blocks by seemingly randomly oriented fractures, and each fractured area has subsided 1-2 km as though support had been withdrawn from beneath. Issuing from the chaotic region are the largest channels on Mars. By comparison with terrestrial periglacial flood features, these channels have been attributed to massive release of subsurface water. Large channels occur elsewhere particularly in the primitive cratered terrain. Their wide spacing and absence of distributary systems with dimensions comparable to the size of the main channels make origin by surface runoff of rainfall unlikely. However, myriads of fine channels throughout the equatorial region argue for an atmospheric origin for water.

The polar regions are quite unlike the rest of the planet. The caps, composed mostly of CO_2, advance and recede with the seasons. As the caps recede in the spring, they uncover a series of distinctively polar deposits. Because the imagery is difficult to interpret, there is considerable uncertainty about the geometric relations, but the following general picture has emerged. Sitting unconformably on the underlying nonpolar materials are the "etch-pitted deposits" whose surface is smooth and level except for irregularly shaped pits and craters. In most places, the etch-pitted terrain is overlain by laminated deposits whose surface is smooth and crater free. The fine layering of the laminated deposits are exposed mainly at their equatorward edge. Overlying the laminated deposits is the present emphemeral cap. Both the laminated and the etch-pitted deposits have been interpreted as a residuum of less volatile components of the cap, mixed with aeolian debris. The layering may preserve a record of past climatic changes.